3.3.8 Rangeland Vegetation

The management style in the watersheds leaves large amounts of biomass, in the form of standing vegetation. In view of the area's Mediterranean climate and prevalence of cool-season grasses and forbs, spring biomass values tend to reflect growth, while fall numbers probably are more indicative of grazing practices and sampling schedule. Nonpersistent litter aids plants by reducing evaporation from the soil surface, acting as a mulch or barrier between the soil and atmosphere. Nonpersistent litter benefits the soil (and ultimately, plants) by reducing soil surface crusting, moderating soil temperature, and increasing the diversity of the soil microbial community. It is also beneficial in reducing the impact of raindrops, lessening detachment of soil particles by splash erosion. It serves as a source of nutrients, as it decomposes and nutrients are mineralized. Of the rangeland parameters, bare ground bears the most direct relationship with water quality as well as to range quality. Susceptibility of the soil particles to detachment by raindrop splash and transport by overland flow is much higher in bare ground than under vegetation or litter. The relative amounts of grasses and forbs, and the diversity of species of each, were measured throughout the study as being indicators of habitat quality Generally, in a healthy grasslands ecosystem, we would expect more forbs, and a greater number of different plant species. Purple needlegrass (*Nassella pulchra*), the only native bunchgrass present on the transects in the paired watersheds, was assessed as a desirable species. Thistles were assessed as undesirable plants.

A wide variety of plants were inventoried in the paired watersheds (Appendix 3.1). These included 14 grass species, 6 grass-like plants, 57 forb species, 8 shrubs, and 5 trees. Of the annual grasses, annual Italian ryegrass (*Lolium multiflorum*), soft chess *brome (Bromus hordaceous*), and false brome (*Brachypodium distachyon*) were dominant. The native perennial grass, purple needlegrass, was the dominant perennial grass.

When transect pairs were compared, statistical significance was very poor. With treatment as the only predictor variable, no differences between Chumash and Walters were significant. With covariables, very few differences were significant. Results are tabulated below (Table 3.20).

No pattern is evident with respect to the few significant findings, except possibly plant height (Fall) in transect pairs 1 and 3, and grasses (Fall) in transect pairs 1 and 2. Approximately 100 regression analyses were run; we would expect significant results by chance alone about 5 percent of the time, and as the results in Table 3.15 show, we had only a few more significant findings.

Poor statistical results primarily were due to low number of observations - 2 to 3 years pre-BMP, 6 years post-BMP. Also, the number of variables besides treatment, only a few of which were factored into the regression analyses, is considerable. These would include soil water holding capacity which itself depends on many factors, subtle differences in rainfall distribution between the watersheds, other climatic factors such as temperature and wind, topographic factors such as slope and aspect, and the experience and expertise of data collectors. Pairing the transects was an attempt to eliminate variables related to soils and topography; however, natural physiographic variations make it impossible to find truly identical pairs with this type of study design.

Table 3.20. P values of regression analyses, range data, spring (upper) and fall (lower).
Regression equations are given in Appendix X. Rainfall (R), forage consumption (C), and forage consumption divided by square root of time since previous grazing (Ct) were covariables with treatment (T). Treatment was either before or after BMP implementation, with July 1, 1996 as the date of implementation. Results are significant (P value in **bold**) if P ≤ 0.05. Negative sign in parentheses indicates the response variable was greater in Walters watershed than in Chumash.

Spring

Response variable	T and R	T and C	T and Ct	Response variable	T and R	T and C	T and Ct
Biomass				Total grasses			
RC1-RW1	**0.03** (-)	0.14 (-)	0.09 (-)	RC1-RW1	**0.05** (-)	0.09 (-)	0.10 (-)
RC2-RW2	0.86 (-)	0.39 (-)	0.38 (-)	RC2-RW2	0.51 (-)	0.52 (-)	0.74 (-)
RC3-RW3	0.296 (-)	0.98 (-)	0.58 (-)	RC3-RW3	0.92 (-)	0.30 (-)	0.74 (-)
RC4-RW4	0.17 (-)	no data for C	no data for Ct	RC4-RW4	0.57		
Plant height				Total forbs			
RC1-RW1	**0.016** (-)	0.17 (-)	0.16 (-)	RC1-RW1	0.33	0.42	0.46
RC2-RW2	0.72 (-)	0.88	0.57	RC2-RW2	0.74 (-)	0.76 (-)	0.87
RC3-RW3	0.73	0.26	0.50	RC3-RW3	0.23 (-)	0.89	0.99
RC4-RW4	0.49 (-)			RC4-RW4	**0.02** (-)		
Vegetative density				Purple needlegrass			
				RC1-RW1			
RC1-RW1	0.72 (-)	0.95	0.81 (-)	RC2-RW2	0.97	0.79 (-)	0.70 (-)
RC2-RW2	0.41 (-)	0.34 (-)	0.33 (-)	RC3-RW3	0.45	0.34	0.43
RC3-RW3	0.43	0.80	0.78	RC4-RW4	0.66 (-)	0.46 (-)	0.42 (-)
RC4-RW4	**0.04** (-)				0.99 (-)		
Bare ground				Thistle			
RC1-RW1	0.94	0.93 (-)	0.80 (-)	RC1-RW1	0.68	0.85	0.97 (-)
RC2-RW2	0.86 (-)	0.75 (-)	0.88	RC2-RW2	0.90 (-)	0.56 (-)	0.67 (-)
RC3-RW3	0.33 (-)	0.23 (-)	0.21 (-)	RC3-RW3	**0.03** (-)	0.86 (-)	0.71 (-)
RC4-RW4	0.42 (-)			RC4-RW4	0.71		
Nonpersistent litter				Number of plant species			
RC1-RW1	0.66	0.84	0.82	RC1-RW1	0.59 (-)	0.37 (-)	0.22 (-)
RC2-RW2	0.63 (-)	0.42 (-)	0.41 (-)	RC2-RW2	0.93	0.83	0.67
RC3-RW3	0.46	0.91	0.76	RC3-RW3	**0.02** (-)	0.29 (-)	0.20 (-)
RC4-RW4	0.54 (-)			RC4-RW4	0.24 (-)		

Fall

Response variable	T and R	T and C	T and Ct	Response variable	T and R	T and C	T and Ct
Biomass				Nonpersistent litter			
RC1-RW1	0.59 (-)	0.29 (-)	0.32 (-)	RC1-RW1			
RC2-RW2	0.65	0.68	0.79	RC2-RW2	0.16	**0.05**	0.07
RC3-RW3	0.67 (-)	0.45 (-)	0.44 (-)	RC3-RW3	0.62	0.71	0.67
RC4-RW4	0.30 (-)			RC4-RW4	0.25	0.36	0.32
					0.75		
Plant height				Total grasses			
RC1-RW1	**0.03** (-)	**0.03** (-)	**0.05** (-)	RC1-RW1	0.098 (-)	**0.008** (-)	**0.02** (-)
RC2-RW2	0.73	0.50	0.50	RC2-RW2	0.099 (-)	0.31 (-)	0.104 (-)
RC3-RW3	**0.02** (-)	**0.007** (-)	0.08 (-)	RC3-RW3	0.99	0.93 (-)	0.86 (-)
RC4-RW4	0.99 (-)			RC4-RW4	0.41		
Vegetative				Total forbs			
density				RC1-RW1	0.48	0.72	0.74
RC1-RW1	0.70 (-)	0.43 (-)	0.57 (-)	RC2-RW2	0.59	0.51	0.51
RC2-RW2	0.72	0.96 (-)	0.96 (-)	RC3-RW3	0.57 (-)	0.95	0.90
RC3-RW3	0.44 (-)	0.53 (-)	0.51 (-)	RC4-RW4	0.93 (-)		
RC4-RW4	**0.03** (-)						
Bare ground							
RC1-RW1	0.54 (-)	0.34 (-)	0.36 (-)				
RC2-RW2	0.69	0.97 (-)	0.78				
RC3-RW3	**0.04** (-)	0.14 (-)	0.16 (-)				
RC4-RW4	0.27 (-)						

In spite of the lack of statistical significance, we did record some striking improvements in rangeland quality, especially in stream corridors, in the Chumash watershed (Fig. 3.35a). Photodocumentation of the Walters watershed shows no improvement, and is included below for comparison (Fig. 3.35b). Both of the transects illustrated below are representative of riparian zone conditions throughout the respective watersheds. In Chumash, streambanks have revegetated, and cattle trails and streambank slough scars have partially healed. Channel bottoms have revegetated. In particular, willows have proliferated in the channels.

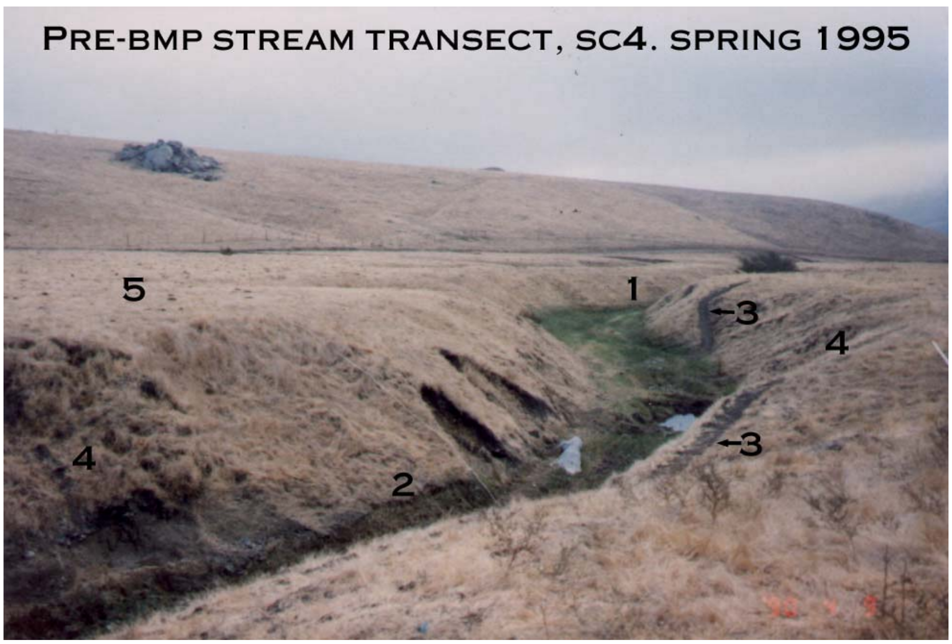


Figure 3.35a. Pre- and post-BMP implementation (1995 and 2001, respectively), stream transect SC4, Chumash watershed (treatment).
Explanation of features: 1, willow establishment has expanded. 2, proliferation of vegetation in the stream channel has decreased streambank sloughing. 3, vegetation of cattle trails. 4, proliferation of vegetation in scars 5, less evidence of manure piles at bank tops indicate effective rotational rest periods, also illustrated by increase in grass cover.

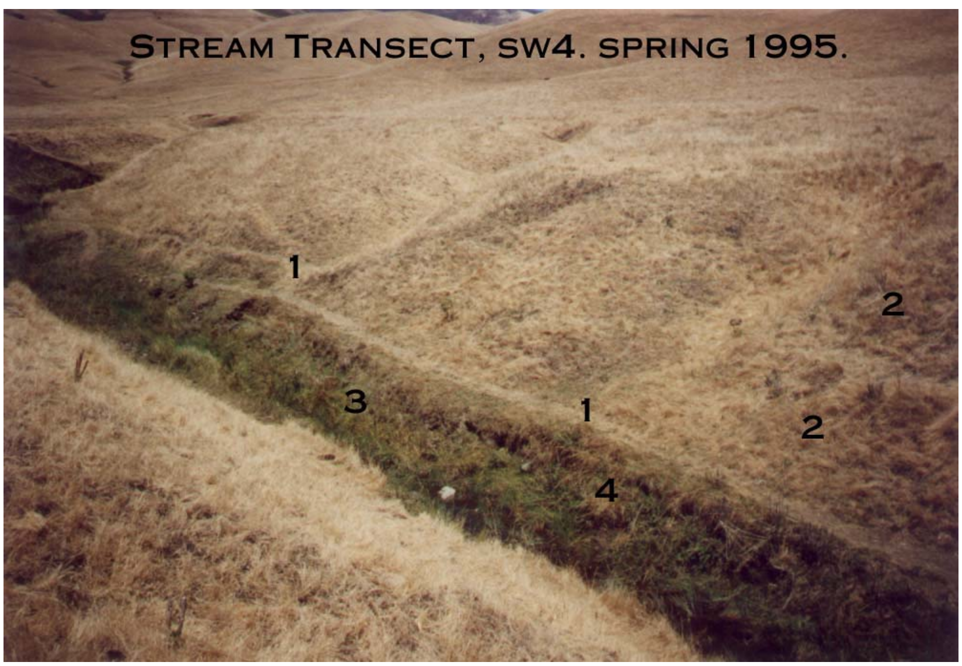
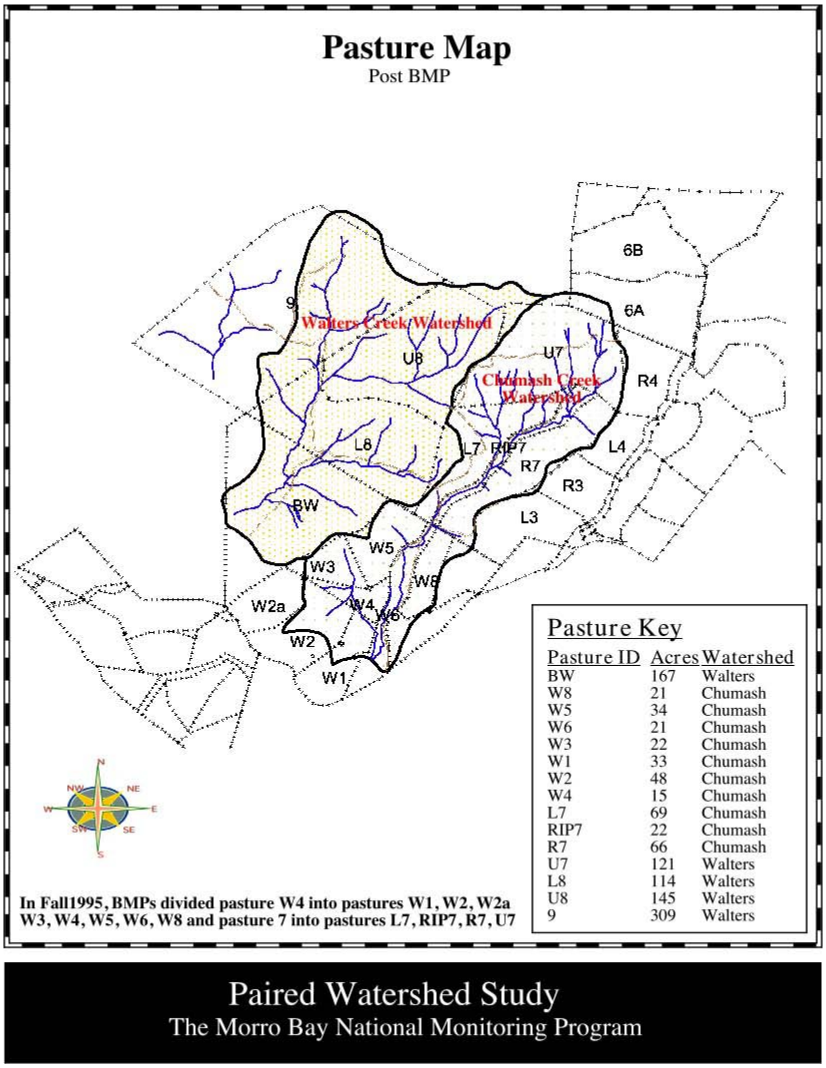
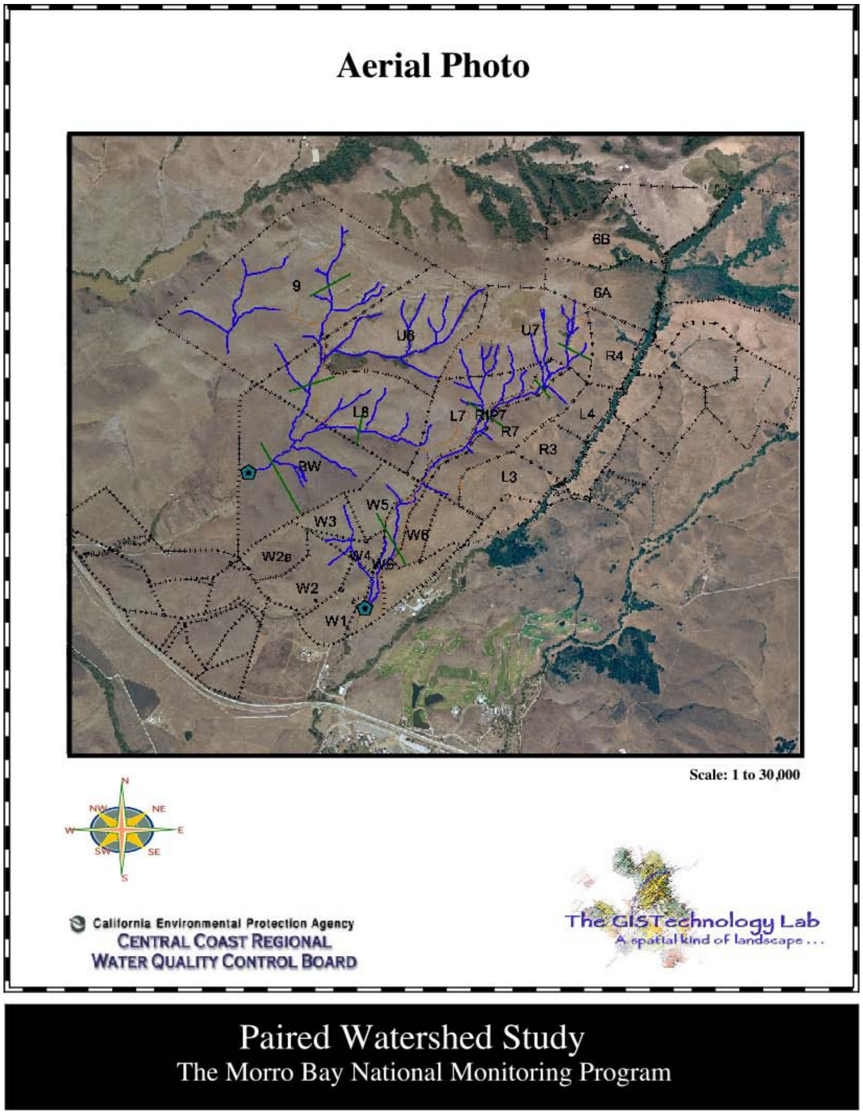


Figure 3.35b. 1995 (upper) and 2001 (lower) photographs of stream transect SW4, Walters watershed (control). Explanation of numbered features: 1, cattle trails have not healed. 2, soil trampling near cattle trails is more evident in 2001. 3, no expansion of stream corridor vegetation has occurred. 4, incidence of stream bank sloughing has increased near cattle trail.

Geographical Information Systems

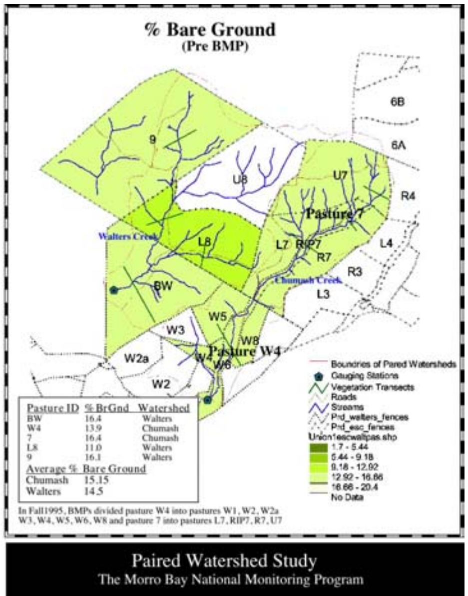
A wide range of data for the watershed was mapped from various data sources. The foundation for the GIS data base included slope gradients, aspects (aspect is the direction a slope faces), soils, elevation contours, and major road locations. These data were entered onto GIS from published sources by Cal Poly's Landscape Architecture Department, previous to and independently of the NMP. The Cal Poly Natural Resource Management Department expanded the database by using Global Positioning Systems (GPS) technology to map features such as vegetation, roads, streams, fences, pastures, and riparian BMPs. Rangeland transects also were mapped using GPS. Post BMP pastures have been superimposed on a map of the paired watersheds, showing (in addition to the pastures) the watershed divide and streams. Post BMP pastures and rangeland monitoring transects were superimposed on the aerial photograph of the paired watersheds. Slope gradients (arbitrarily grouped into slope classes of High, Medium, and Low) and aspects are also shown with pastures superimposed. The main value of these maps is to show substantial amounts of geographical information in a concise manner.

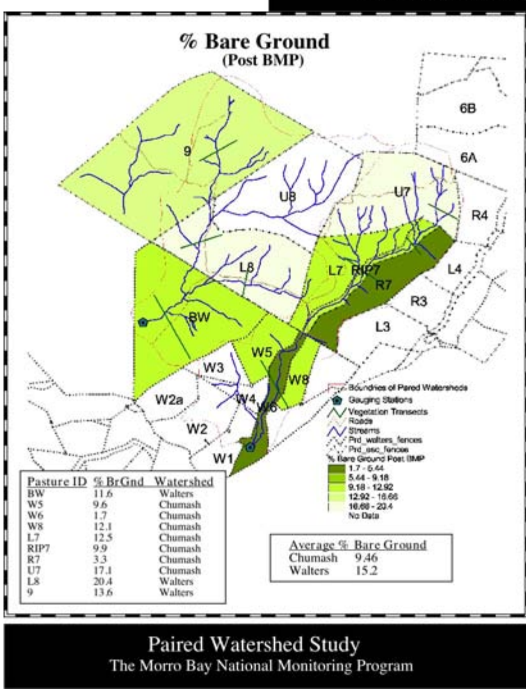

Pasture Map
Post BMP
6B
6A
9
Walters Creek Watershed
U8
U7
Chumash Creek Watershed
R4
L8
L7
RIP7
L4
R7
R3
BW
L3
W5
W3
W8
W2a
W4
W6
W2
W1
N
NE
E
SE
S
SW
W
NW
Pasture Key
Pasture ID Acres Watershed
BW 167 Walters
W8 21 Chumash
W5 34 Chumash
W6 21 Chumash
W3 22 Chumash
W1 33 Chumash
W2 48 Chumash
W4 15 Chumash
L7 69 Chumash
RIP7 22 Chumash
R7 66 Chumash
U7 121 Walters
L8 114 Walters
U8 145 Walters
9 309 Walters
In Fall1995, BMPs divided pasture W4 into pastures W1, W2, W2a W3, W4, W5, W6, W8 and pasture 7 into pastures L7, RIP7, R7, U7
Paired Watershed Study
The Morro Bay National Monitoring Program



The rangeland data were used to develop maps of the pastures showing rangeland parameters (for example, bare ground, percent forbs, percent grasses). Using the locations of the pastures and transects, tabular range vegetation data were spatially joined to the pasture GIS data. This enabled pre and post BMP rangeland characteristics to be mapped. In order to present the data in a pre versus post BMP manner, we had to make the assumption that the transects were representative of pasture conditions, especially in view of the fact that the transects were established before the pastures in Chumash were delineated. Based on on-the-ground observations, we judged this assumption to have been reasonable. This type of analysis using GIS concisely reveals that, in the Chumash watershed, bare ground decreased in the riparian pastures and in W5, W8, L7, and R7. Bare ground did not appear to decrease measurably in the upland pasture U7, and in the southern pastures W1, W2, W3, and W4. Observed cattle behavior may explain this: given a choice (that is, pre BMPs) cattle roaming freely prefer riparian and nearby areas, because of the availability of water, lusher vegetation, and shade in these areas. Thus, the riparian and contiguous pastures were impacted more heavily by cattle before BMP implementation. When cattle access to these pastures was controlled, vegetation recovered.

Even though the results were not shown to be statistically significant, clearly, progress in rangeland improvement has been made.





Changes in grasses/forbs abundance are evident, but since forbs have increased in both Walters and Chumash watersheds, seem less a function of BMP implementation. In general, we consider the increase in forbs to be a positive result, as a measure of an increase in biodiversity in the watersheds.

Cal Poly's Animal Science Department used GIS software as a tracking and management tool, for cattle in the paired watersheds. Cattle rotations in the various pastures were tracked over time in the GIS and these data was used to record and map cattle density. The displays not only give resolution and specificity, but also provide the information and display it visually, with easy access to related geographical information.

Forage Quality

Percent moisture in the air-dried samples did not differ by season, year or treatment. Overall average moisture percent was 9.2.

Moisture

	Fall		Spring	
Year	Walters	Chumash	Walters	Chumash
1998	9.0	9.3		9.3
1999	8.7	8.9	9.3	9.3
2000	9.1	9.3	9.3	9.2

ADF and NDF differed by season (p<.05) but did not differ by year or treatment. Seasonal differences are likely due to increased lignification of the forages, thereby decreasing nonfiber components of the plant as desiccation occurs.

ADF - Dry Matter

	Fall		Spring	
Year	Walters	Chumash	Walters	Chumash
1998	55.0	55.2		44.1
1999	51.0	51.6	44.7	42.5
2000	51.2	51.8	39.7	40.2

NDF - Dry Matter

	Fall		Spring	
Year	Walters	Chumash	Walters	Chumash
1998	72.0	72.3		67.3
1999	77.3	74.1	65.6	65.1
2000	75.4	74.4	63.4	60.6

As expected, lignin content of the forages increased during the dry season as forages mature. The lignin ties up cellular components, thereby decreasing the availability of nutritional components of the plant and subsequently reducing value to the grazing animal. Lignin content was significantly effected by season (p<.05). However, watershed and year did not affect lignification.

Lignin - Dry Matter

Year	Fall		Spring	
	Walters	Chumash	Walters	Chumash
1998	17.6	16.0		15.4
1999	16.4	13.7	13.8	10.5
2000	12.1	14.3	7.2	9.4

No differences in nutrient content were detected by fiber analyses. If nutrient contents were affected by implementation of BMPs (specifically grazing practices), they would have been detected by the end of the trial. Since differences were not detected in the last 3 years, the decision was made to not continue testing earlier samples. Further, it was felt that since a primary plant component (fiber) was not affected by implementation of BMPs, differences in crude protein were very unlikely.

The lack of differences in nutrient content between watersheds was due to one of the following:

(1) No differences exist. If this is the case, implementation of BMPs do not detrimentally impact nutrient content of forages.

(2) Evidence of increased nutrient content requires much greater efforts in monitoring. This is either due to inadequate sampling or the need for a greater length of monitoring time to observe differences. We hypothesize that a longer monitoring time would show differences in forage quality.

(3) Differences may exist, but even time grazing of Walters and Chumash watersheds (plus Pennington) by the Escuela herd made the differences undetectable in the study design. This would encourage the initiation of a subsequent paired study with separate cow herds.

Finally, nutrient content on a percentage basis provides only a partial projection of availability to grazing animals. Total nutrient availability is the product of the percentage of ADF, NDF, etc. and the residual dry matter. Implementation of BMPs clearly increase total dry matter production of forages on the rangeland. Even with no significant changes in nutrient content, total nutrient availability is increased.

3.3.9 Stream Channel Profiles

Examination of stream channel cross sectional profiles of typical reaches show minor alterations in stream channels have occurred (Fig. 3.36 and 3.37). These alterations include bank erosion, and both channel bottom infilling and downcutting - sometimes both occurring in the same channel. Alterations have occurred in both Walters and Chumash Creeks; no systematic changes can be identified as a result of BMP implementation.

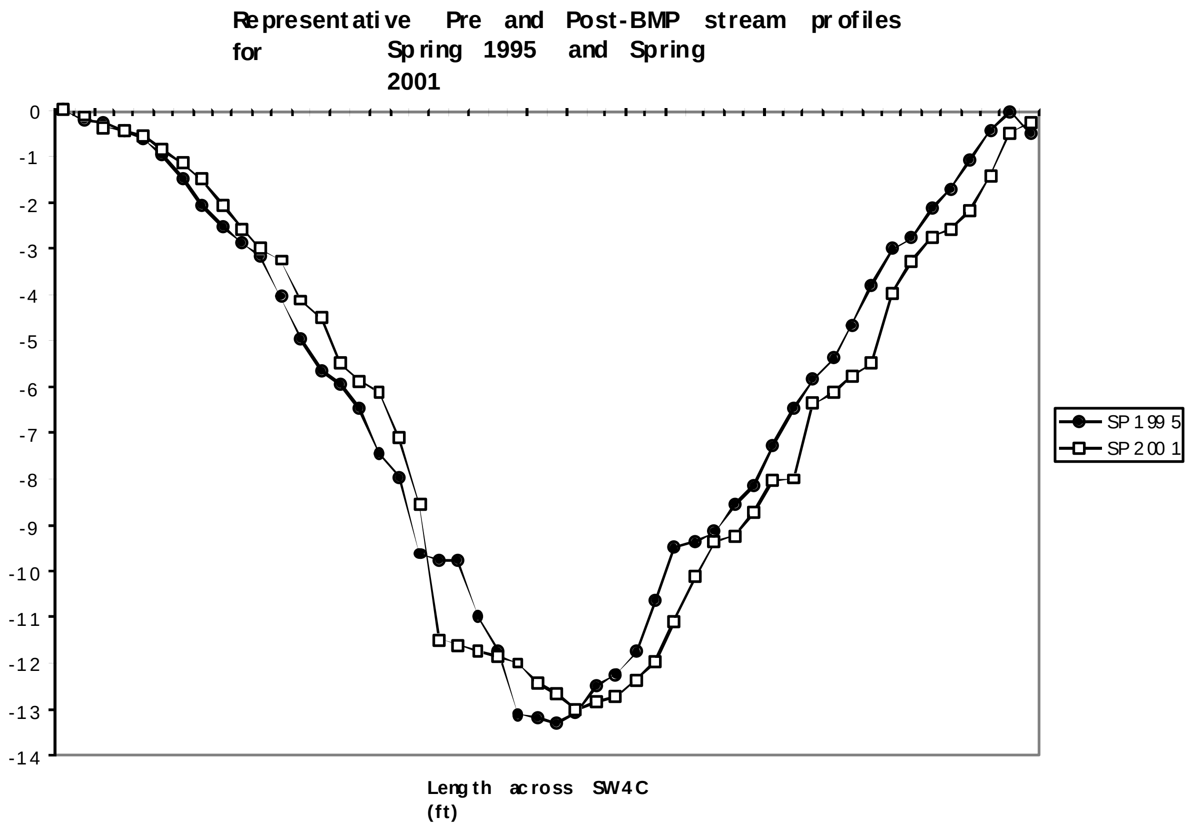


Figure 3.36. Stream channel cross-sectional profile, Walters Creek, stream transect SW4C. Streams were surveyed annually, but only two years, one pre- and one post-BMP, are shown, for clarity. Horizontal distance is shown at top of profile, vertical scale on the left. Both scales are in feet. Vertical exaggeration is approximately 2x.

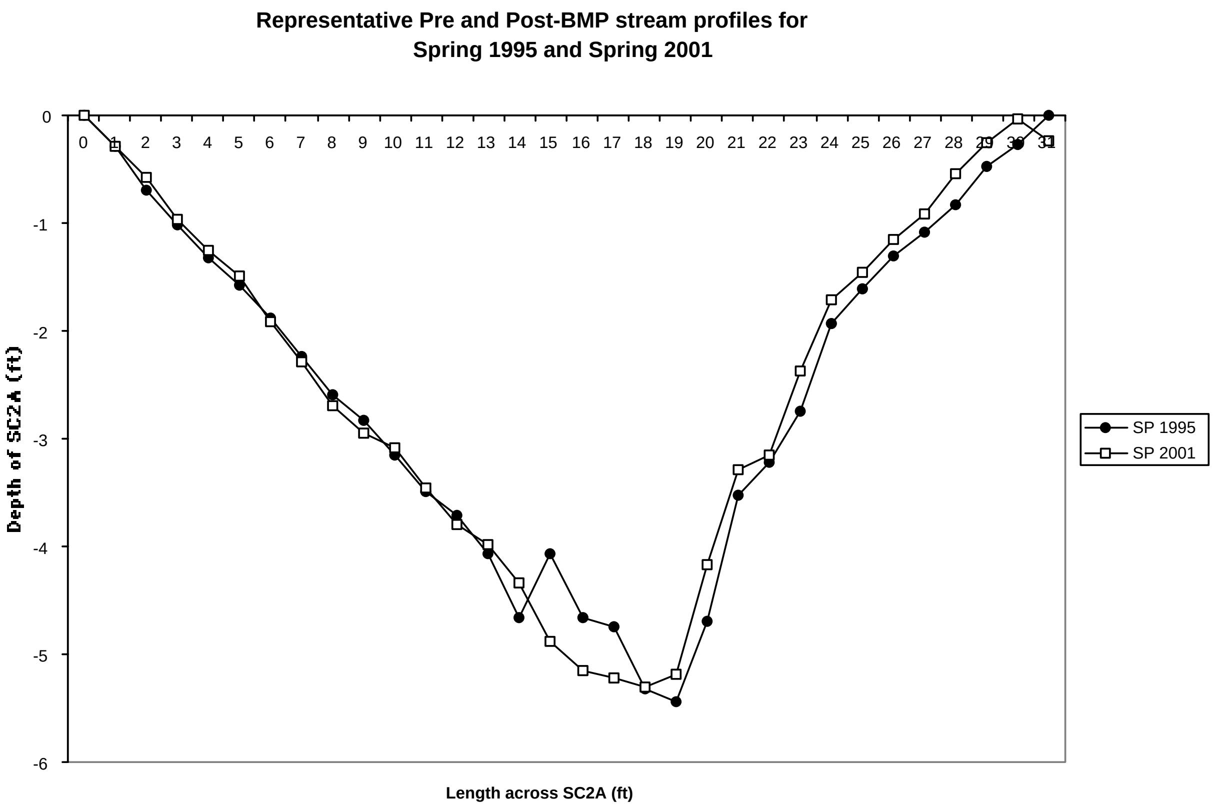


Figure 3.37. Stream channel cross-sectional profile, Chumash Creek, stream transect SC2A. Streams were surveyed annually, but only two years, one pre- and one post-BMP, are shown, for clarity. Horizontal distance is shown at top of profile, vertical scale on the left. Both scales are in feet. Vertical exaggeration is approximately 2x.

3.3.10 Channel Stability Evaluations

Average Pfankuch ratings for Chumash show positive results post-BMP implementation, suggesting that BMPs have been effective in improving stream stability (Fig. 3.38). In the Pfankuch system, low numbers indicate a more favorable stream stability rating, high numbers are unfavorable. In the spring evaluations, we note a general decrease in Chumash ratings, and in spring 2001, Chumash ratings were substantially lower than Walters ratings. No statistically significant relationships were shown, in paired transects.

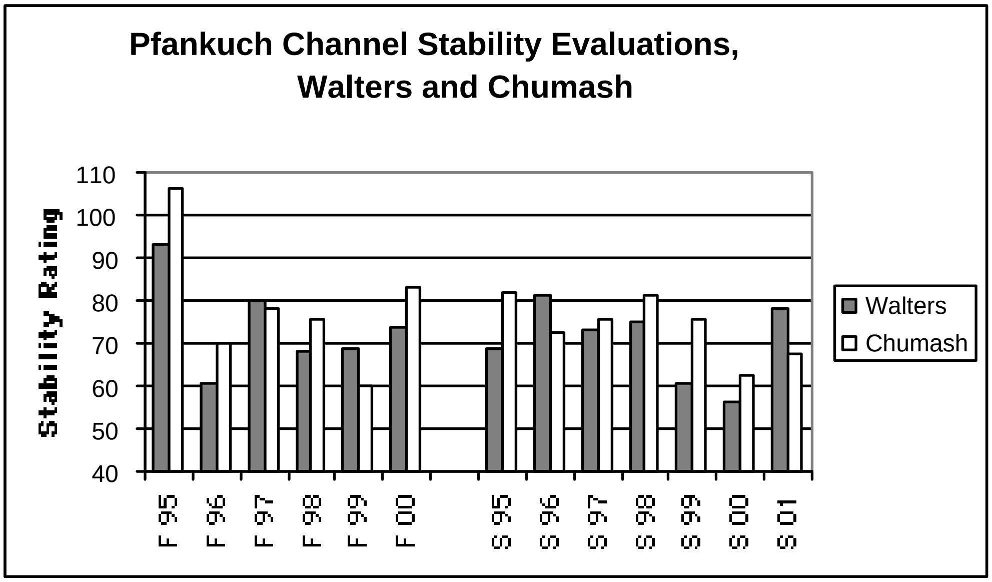


Figure 3.38. Pfankuch channel stability evaluations, Walters and Chumash Creeks. Low numbers are favorable, high numbers are less favorable.

3.4 Overall Paired Watershed Conclusions

The paired watershed study was used to assess the effects of land treatment measures (BMPs) on water quality and range and habitat quality. Water quality data were collected on both event-based and even-interval bases. Improvements in event-based water quality parameters turbidity and suspended sediment began almost immediately after BMP implementation. We did not see water quality improvements for all parameters at Chumash as soon as they were implemented, as BMPs were installed incrementally during 1995-1996, and some in fall 1997. Even once established, BMPs take a while to take effect, as riparian and grassland vegetation develops and stream channel stability improves. Water quality improvements increased each season until 1999, at which time improvements leveled off. The final year of monitoring, 2001-2002, was so dry that no water quality samples could be collected.

The controlled grazing appears to be associated with a decrease in bare ground and an increase in nonpersistent litter. Cal Poly staff expect that, eventually, decreases in bare ground, and increases in nonpersistent litter would improve soil fertility, and correspondingly improve forage quality.

Improvements in the rangeland and stream corridors, specifically vegetative cover of streambanks and healing cattle trails and minor streambank slump scars, are visually striking. However, the results are not statistically significant. The lack of statistically supported correlation of response variables to treatment and other quantifiable variables (such as rainfall), probably is due to the low number of observations (each year constituted an observation), especially pre-BMP, and possibly also to other, unforeseen, variables.

The paired watershed project had six objectives: (1) demonstrate a variety of simple, cost-effective BMPs, accessible to landowners, for controlling soil erosion and sediment, (2) successfully reduce sediment and turbidity levels, water temperature, fecal coliform, and nutrient concentrations (3) maintain healthy levels of dissolved oxygen (4) improve riparian and in-stream habitat, benthic invertebrate assemblages, and rangeland quality (5) promote multiple use objectives and demonstrate that grazing is compatible with revegetation and habitat improvement, and (6) achieve enterprise profitability linked to sound resource management.

The first objective was met, with the provision that cost-effectiveness of the BMPs will largely depend on the goals of the land owner/manager, the land use history, the resources available to the land owner/manager on premises, and perhaps the availability of cost-share funding.

The second objective , to reduce sediment, turbidity, water temperature, fecal coliform, and nutrient concentrations, was largely met. Event-based suspended sediment and turbidity were reduced. Based on event-based data, improvements in water quality began almost immediately after BMP implementation, continued each season, then leveled off as streambank vegetation established a nearly continuous cover. Under the unique set of climate and physiographic conditions, the plateau took about 4 years following controlled cattle grazing in the riparian zone.

Turbidity was reduced during storm-events, but these reductions were not found during low flow periods using the even-interval sampling scheme, as it is expected that BMPs are most likely to affect turbidity during storm events when most sediment is transported. When the second threshold value of 7 NTUs was examined, a significant difference was found in turbidity during the post-BMP time period. The increase in turbidity during low flow periods may possibly be related to an improvement in overall habitat quality, and the increased plant growth and decay associated with the dynamically changing riparian plant community.

The objective of improving water temperature at Chumash Creek due to BMP implementation was met. The objective of lowering fecal coliform bacteria was not met possibly due to grazing practices in the upper Chumash watershed or potential increases in birds and wildlife. Increases in nitrate-nitrogen may be indicative of early riparian succession at Chumash Creek.

The objective of maintaining healthy levels of dissolved oxygen was met. While Chumash Creek dissolved oxygen levels declined post-BMP implementation, values were less variable in the post-BMP time period than the pre-BMP time period. Additionally, Walters Creek has supersaturated conditions, with a greater variance than Chumash Creek.

The fourth objective, to improve riparian and in-stream habitat, benthic invertebrate assemblages, and rangeland quality, was largely met. The riparian zones in Chumash are improved, especially demonstrated by photodocumentation. Improvements in riparian vegetation and rangeland quality were not, however, statistically significant. Possibly, a longer monitoring period, especially pre-BMP, would have given statistically significant results. Nevertheless, improvement in the range and especially in the stream corridors, is evident. The absence of Rapid Bioassessment data from the pre-BMP period made it difficult to draw conclusions about benthic invertebrate assemblages.

The fifth objective was to promote multiple use objectives and demonstrate that cattle grazing is compatible with revegetation and habitat improvement. Rangeland and riparian habitat quality have improved. Results were not statistically significant, for reasons described above. However, the Cal Poly team feels this objective has been met. We have demonstrated improvements in event-based water quality, which impacts channel bottom habitat. Bare ground decreased in Chumash, compared to Walters.

The sixth objective was to achieve enterprise profitability with this style of resource management. Certainly, supplemental feed costs have continued to decline throughout the monitoring period, but we cannot say that it is a function of the management, as differences between the two watersheds were subtle, and the same group of cattle were used throughout. Some intangible benefits of the rotational grazing style have been realized, such as increased cattle docility.